



Implementation of the Orbital Maneuvering System Engine and Thrust Vector Control for the European Service Module

Jon Millard
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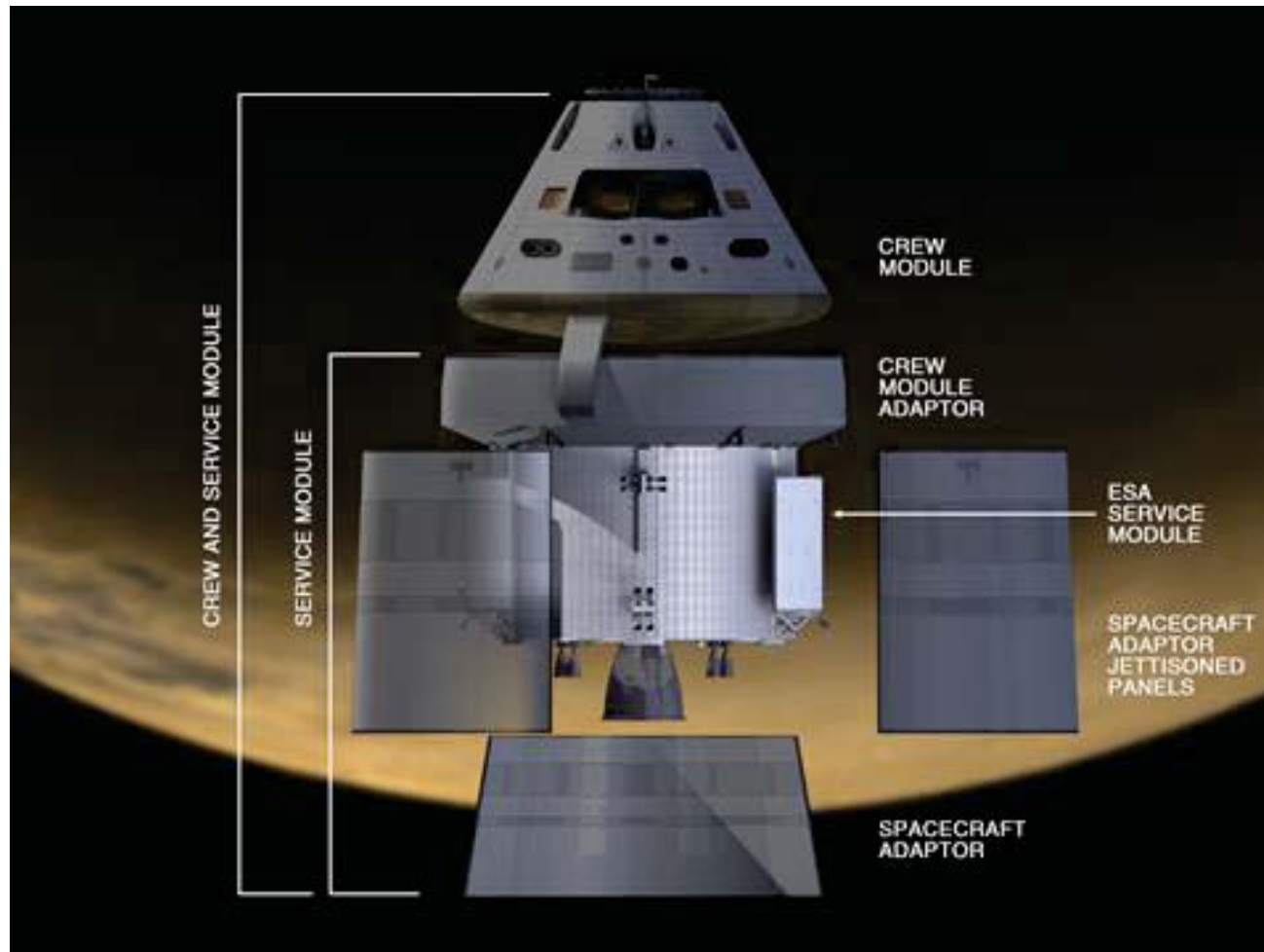
- **NASA propulsion hardware obligations for ESM**
- **Hardware Overview**
- **Design Description and Interface Document**
- **Implementation**
- **Current Status**
- **Conclusion**



Crew and Service Module



Multi-Purpose Crew Vehicle (MPCV)





Hardware Obligations



Multi-Purpose Crew Vehicle (MPCV)

- **Under BHSEALS, NASA is obligated to provide ESA**
 - Two (2) OMS-E assemblies for EM-1 and flight spare
 - One (1) OMS-E assembly for propulsion system ground testing
 - One (1) OMS-E assembly for EM-2
 - Two (2) TVC assemblies for EM-1 and flight spare
 - Two (2) TVC assemblies for developmental testing
 - One (1) TVC assembly for EM-2
 - Available OMS-E & TVC GSE
 - One (1) OMS-E mass simulator
 - One (1) OMS-E electrical simulator

- **Under BDEALS, NASA is obligated to provide ESA**
 - OMS-E & TVC design documentation, drawings, and operational histories
 - Models to support performance, structural, and thermal analysis

BILATERAL HARDWARE and SOFTWARE EXCHANGE AGREEMENTS, LISTS, and SCHEDULES (BHSEALS)

BILATERAL DATA EXCHANGE AGREEMENTS, LISTS and SCHEDULES (BDEALS)



Hardware Overview



Multi-Purpose Crew Vehicle (MPCV)

■ OMS-E Assembly

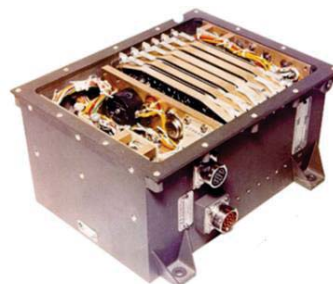
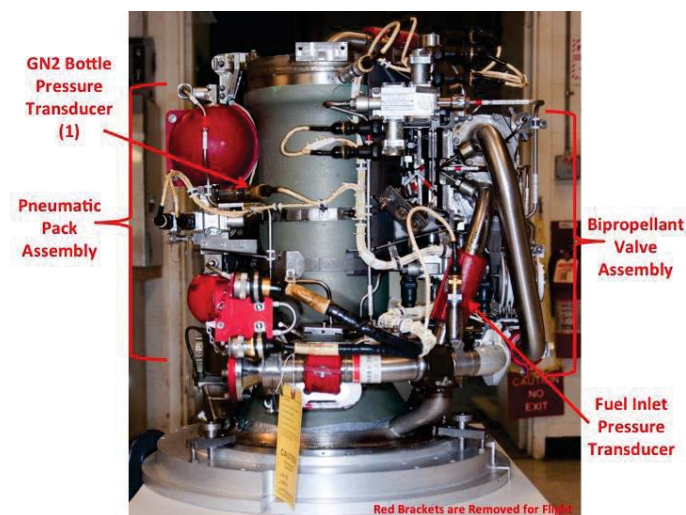
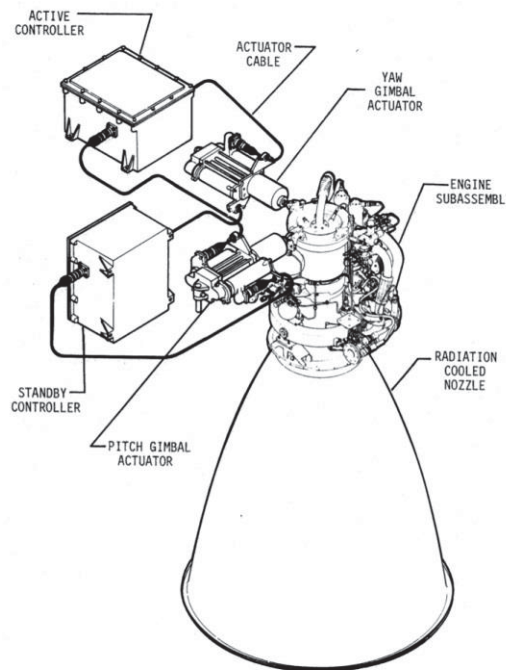
- Engine Subassembly
 - Pneumatic Pack, TCA, BPV, gimbal ring, service lines, and instrumentation
- Nozzle Extension
- Heat Shield Assembly

■ TVC Assembly

- Pitch Gimbal Actuator
- Yaw Gimbal Actuator
- Active Actuator Controller Unit
- Standby Actuator Controller Unit
- Electrical Harnesses

■ GSE

- Engine Installation GSE
- Leak Check/Purge GSE
- Protective GSE
- TVC GSE
- Shop Aides
- Shipping Containers





Implementation of the Orbital Maneuvering Systems Engine and Thrust Vector Control for the ESM



Multi-Purpose Crew Vehicle (MPCV)

- **Design Description and Interface Document (DDID) Overview**



Design Description and Interface Document



Multi-Purpose Crew Vehicle (MPCV)

- **Design Definition and Interface Document (DDID) will serve as the single source for the design characteristics and interface requirements for the heritage engine and TVC assemblies**
- **Complete description of design characteristics**
 - Product and functional descriptions of subassemblies, components (including GSE)
 - Mechanical, thermal, electrical design characteristics
 - Performance, life characteristics
 - Operational envelopes, operational constraints
 - Induced and natural environments
 - Logistics characteristics
- **DDID will provide interface requirements to the vehicle**
 - DDID requirements will flow to subsystem specifications
 - DDID requirements flowed to propulsion system specification will flow to engine and TVC specifications
 - DDID will also serve as the verification document for compliant engine and TVC requirements





Design Description and Interface Document



Multi-Purpose Crew Vehicle (MPCV)

- **Design characteristics and interface requirements/verification will be sourced**
 - Traceability back to Rockwell specification for requirements
 - Traceability back to qualification reports and certification requests for verification

- **DDID will be peer reviewed within NASA**
 - Certify the design and interface characteristics are representative of the heritage hardware design

- **If modifications or delta qualifications to the heritage hardware are needed for ESM, they will be documented in the Definition File (DF)**
 - DF along with DDID will be implemented as a part of the ESM Verification Compliance Document (VCD)



Implementation of the Orbital Maneuvering Systems Engine and Thrust Vector Control for the ESM



Multi-Purpose Crew Vehicle (MPCV)

- **Implementation Overview**



Implementation Overview



Multi-Purpose Crew Vehicle (MPCV)

- **5 Key areas to implement the heritage HW**
 - Areas consists of task that are NASA led, Airbus led, or Joint
- **Secure and Maintain Heritage Hardware**
 - Establish inventory in secured storage, maintain inventory until transfer, provide documentation on design and operational history (NASA)
- **Evaluate Suitability of Heritage Hardware Design for ESM**
 - Establish heritage hardware design characteristics (NASA)
 - Develop technical specification for ESM main engine/TVC (Airbus)
 - Identify areas of heritage hardware design non-compliance with ESM (Joint)
 - Develop and execute plans to resolve non-compliances (Joint)
 - Certify heritage hardware is suitable for ESM application (Joint)
- **Select and Prepare Units for Transfer to ESA**
 - Develop selection criteria for units to be transfer (NASA)
 - Prepare units per ATP's (Shuttle-era w/ any ESM-specific mods) (NASA)
 - Conduct pre-ship/hardware acceptance reviews before each transfer (Joint)



Implementation Overview



Multi-Purpose Crew Vehicle (MPCV)

■ Develop Assembly, Integration, and Test Procedures

- Provide summarized versions of Shuttle-era AI&T procedures (NASA)
- Provide descriptions of available heritage GSE (NASA)
- Develop ESM-specific logistics and installation procedures (Airbus)
- Identify and develop new, ESM-specific GSE (Airbus)
- Develop procedures for ground tests (Airbus)

■ Install and Maintain Transferred Units

- Install ground test and flight units per developed AI&T procedures (Airbus)
- Provide engineering support during installation and test activities (NASA)
- Provide engineering support in response to anomalies during installation and test activities (NASA)



Gimbal Test Set



Engine Install



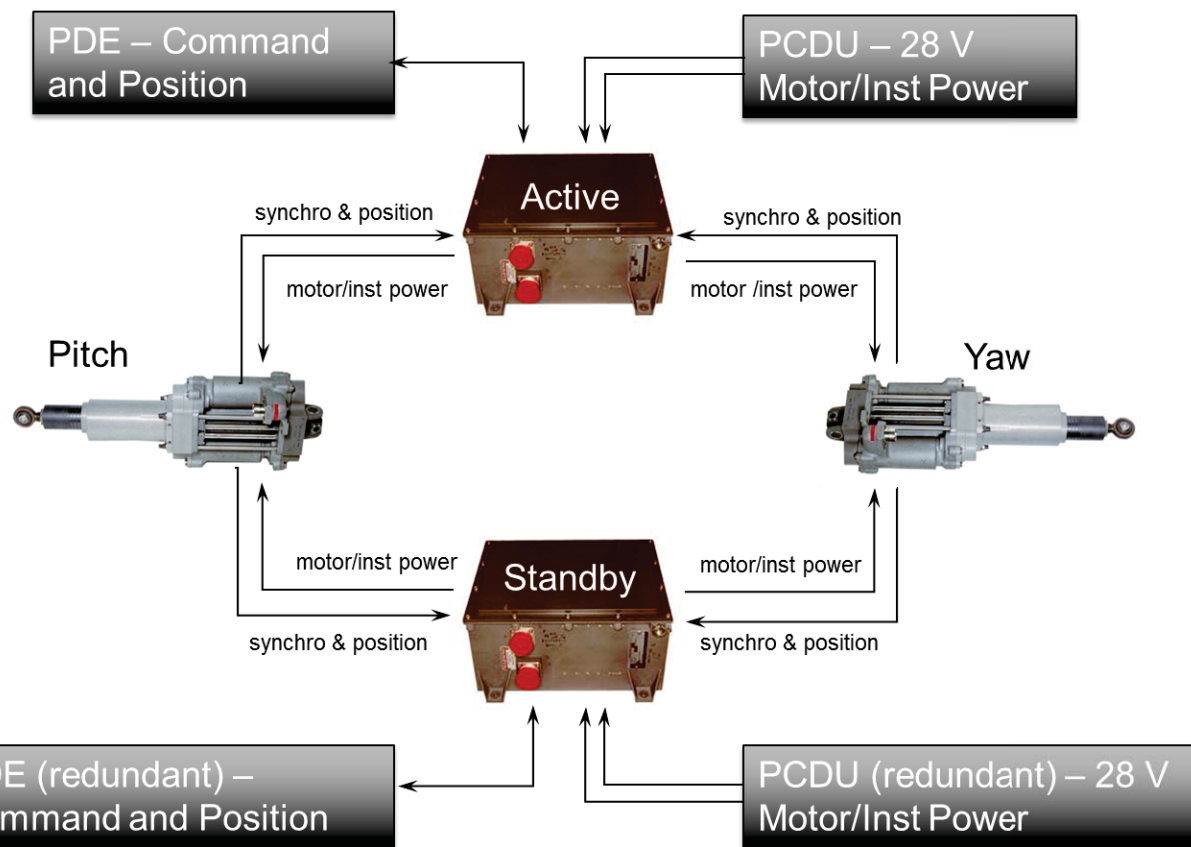
Nozzle Cover



Implementation Overview



Multi-Purpose Crew Vehicle (MPCV)



- **Evaluation tasks to determine the suitability of the GFE can be grouped into several broad areas**
 - Mechanical Flight Environments
 - Thermal Flight Environments
 - Radiation Flight Environments
 - SSP vs ESM Interfacing Avionics
 - Engine and TVC Performance
 - Mission Life Capability (Pneumatic Pack Capability)
 - Maximum Design Pressure
 - Shelf Life Evaluation
 - Remaining Operating Life
 - Electromagnetic Compatibility/Electromagnetic Interference
 - Engine Alignment
 - Natural Environments
 - Ground and Transportation Environments
 - Logistics (shipping, packaging, identification, human engineering)
 - Acceptance Test Requirements

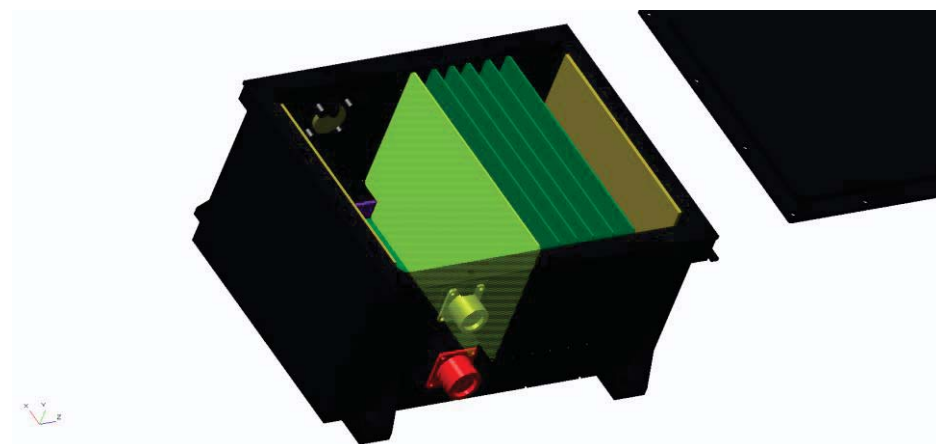


Implementation Overview



Multi-Purpose Crew Vehicle (MPCV)

- **New hardware developments, that are needed to implement the heritage hardware into ESM, have already been identified**
 - OMS-E EGSE (valve actuation, instrumentation)
 - OMS-E Instrumentation
 - TVC Electrical Harnesses (heritage harnesses have insufficient length)
 - TVC EGSE (gimbal actuation; heritage EGSE not recommended for use)
 - Supporting MGSE (e.g., platform for installation stand)
 - Shipping Containers (TVC components, nozzle, GSE)
- **Differences in Shuttle-era and current design and construction standards should be evaluated to understand risks involved in use of heritage hardware for ESM**
 - Materials and Processes
 - Mechanical Design
 - Structural Design
 - Pressure System Design
 - Electrical Design
 - Cleanliness
- **S&MA support will be needed for OMS-E and TVC**
 - FMEA, PRA, Hazards data
 - Support hardware test and integration activities





Current Status



Multi-Purpose Crew Vehicle (MPCV)

- **Initial drafts of engine and TVC specification released**
 - System and Subsystem PDR used to incorporate comments and RIDs
- **Draft DDID (with ESM subsystem interfaces) released for internal and peer review.**
 - Will be revised based on review feedback and baselined for release
- **Equipment Qualification Status Review (EQSR) schedule for early fall 2014**
 - Review used to assess compliance status of GFE with ESM requirements
 - Board approved all plans to resolve noncompliant requirements
- **In parallel suitability of GFE is being evaluated in regards to environments, performance, and life**
- **Shipping container fabrication and GSE revalidation is being conducted**
- **TVC Disassembly and Inspection with basics functional checks**
- **Integration support for all test campaigns associated with the ESM and GFE**





Conclusion



Multi-Purpose Crew Vehicle (MPCV)

- **Many challenges associated with reusing heritage hardware**
 - Heritage design and history, international cooperation, resources, schedule
- **Work required for successful implementation has been identified and mapped to Orion schedule to meet EM-1 launch date.**

